Nitrogen Enriched Quasars in the Sloan Digital Sky Survey First Data Release

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ABSTRACT

The quasar Q0353-383 has long been known to have extremely strong nitrogen intercombination lines at $\lambda 1486$ and $\lambda 1750$ Å, implying an anomalously high nitrogen abundance of ~ 15 times solar. A search for similar nitrogen-rich quasars in the Sloan Digital Sky Survey First Data Release (SDSS DR1) catalog has yielded 20 candidates, including four with nitrogen emission as strong or stronger than that seen in Q0353-383. Our results indicate that only about 1 in 1700 of quasars have nitrogen abundances similar to Q0353-383, while up to 1 in 130 may be in the process of extreme nitrogen enrichment.

Subject headings: galaxies: active — quasars: emission lines — surveys

1. Introduction

The quasar Q0353-383 (Osmer & Smith 1980) is an unusual object, with prominent N III], N IV] and N V emission lines and abnormally weak C III] and C IV lines compared to other quasars. To illustrate this point, Figure 1a displays the spectrum of Q0353-383 (Baldwin, 1992, private

communication) in comparison to a "normal" quasar spectrum given by the Sloan Digital Sky Survey (York et al. 2000) composite in Figure 1b (Vanden Berk et al. 2001). Osmer (1980) concluded that Q0353-383 has an anomalously high nitrogen abundance due to recent CNO processing in stars. Baldwin et al. (2003) used improved data and models to confirm and refine these conclusions, and to determine that Q0353-383 has a metallicity of at least 5 times solar, and more likely 15 times solar. Simulations by Hamann & Ferland (1999) show that this level of overabundance is expected to occur near the end of an era of rapid metal enrichment which can result in metallicities of as much as 10-20 times solar. The scarcity of objects like Q0353-383 may be an indication of the amount of time a quasar spends in this state of extreme metal enrichment before the gas supply is exhausted and the quasar becomes inactive.

As the only object of its kind known, Q0353-383 raises some obvious questions: what percentage of the quasar population is nitrogen strong, and what are the global properties of the nitrogen-strong quasar population? Until recently, anwering these questions was difficult due to the relatively nonstandard collection of quasar data in various wavelength regimes and the lack of spectra with high S/N (signal-to-noise ratio). The advent of the Sloan Digital Sky Survey (SDSS) has remedied this situation by working to compile, in one database, approximately 100,000 highquality quasar spectra as it scans 10,000 deg² of the north Galactic cap (York et al. 2000). Bentz & Osmer (2004) searched the SDSS Early Data Release (EDR, Stoughton et al. 2002) for objects similar to Q0353-383 and determined that although several objects have nitrogen emission that is unusually strong, none of the objects in the EDR Quasar Catalog (Schneider et al. 2002) with 1.8 < z < 4.1 have emission from both N IV] $\lambda 1486$ and N III] $\lambda 1750$ with strengths that are comparable to Q0353-383. In this paper, we have searched for nitrogen-rich quasars in the Quasar Catalog (Schneider et al. 2003) from the First Data Release (DR1, Abazajian et al. 2003), which covers almost three times the area on the sky as the EDR, and has over four times as many quasars. We present numerous objects with stronger nitrogen emission than is usually seen in quasars, including four objects that have emission as strong or stronger than that seen in Q0353-383.

2. Spectral Analysis

The SDSS DR1 Quasar Catalog (Schneider et al. 2003) covers an area of $\sim 1360~\rm deg^2$ of the sky, containing 16,713 objects with luminosities greater than $M_i = -22~\rm mag$ (for a cosmology with $H_0 = 70,~\Omega_M = 0.3$, and $\Omega_{\Lambda} = 0.7$), at least one emission line with a FWHM larger than 1000 km s⁻¹, and reliable redshifts. The entire area scanned for the EDR is contained within DR1, and the quasar spectra from the EDR Quasar Catalog were run through the spectroscopic pipeline again after several modifications and improvements were made. In order to find quasars similar to Q0353-383, we focused our search on objects that exhibited the rest-frame ultraviolet nitrogen intercombination lines at $\lambda 1486$ and $\lambda 1750$. It is important to note that N IV] $\lambda 1486$ and N III] $\lambda 1750$ are collisionally de-excited at densities greater than $\simeq 10^{11}~\rm cm^{-3}$ (Ferland 1999), so it is possible for nitrogen-rich quasars to exist where a strong N V line would be the only indication

(Hamann 1999). However, the detection of objects similar to Q0353-383 would help to set a lower limit on the population of nitrogen-rich quasars based on a larger sample size than previous studies, and further study of such objects could help to increase our knowledge of the end stages of quasar activity.

The SDSS DR1 database was searched for all quasars within the redshift range 1.6 < z < 4.1. This range ensures that both N IV] $\lambda 1486$ and N III] $\lambda 1750$ will be in the 3800-9200Å range observed by the SDSS spectrograph. A total of 6650 objects met the redshift criterion. We used the redshift values determined by Schneider et al. (2003) to correct for cosmological expansion and place the spectra in a common rest frame. As many of the objects in the SDSS are faint and the features we searched for are weak, we first estimated the signal-to-noise (S/N) per pixel (where 3 pixels ≈ 1 Å) of the spectra using the continuum between 1675 and 1725Å. We threw out the noisiest spectra by making a cut at S/N > 3.45, reducing the sample to ~ 5600 quasars. We then ran a cross-correlation routine to compare a 30Å window centered on 1750Å with the same window in the rest frame spectrum of Q0353-383 to test for the presence or absence of an emission features in the location of N III]. ¹ A further cut was made with the twofold criteria of a relative velocity offset less than 850 km s⁻¹ and a cross-correlation coefficient value of at least 0.35 for any feature detected in the N III] 30Å window. The ~ 1350 objects that passed the cuts were then visually inspected in order to verify the presence of emission from nitrogen, as objects with features such as absorption or noise spikes could also be included in the sample. All objects with broad absorptionline profiles were immediately discounted ($\sim 6\%$ of the sample). Only 198 ($\sim 15\%$) of the objects did not seem to have evidence for an emission feature near $\lambda 1750\text{Å}$ upon visual inspection. Objects that appeared to have prominent emission from both species of nitrogen were marked for further inspection.

Finally, equivalent widths of the N IV] and N III] emission lines (W_{NIV} and W_{NIII} , respectively) were measured in the rest-frame spectra using a simple summing function with a two-point continuum interpolation. These are only guideline measurements, and therefore have a typical error of 0.5-1.0Å. Several of the objects that were selected with the cross-correlation method and subsequently passed the visual inspection were found to have relatively large values of W_{NIV} and W_{NIII} . Hereafter, we shall focus on those objects with W_{NIV} and $W_{NIII} \gtrsim 2.0$ Å (see Table 1 for their general properties and Table 2 for emission line measurements). These quasars will hereafter be referred to as nitrogen-rich candidates, and their spectra are displayed in Figure 2. Table 3 lists another group of quasars that we shall refer to as nitrogen-salient quasars. These objects have obvious emission from at least one of the species of interest, but do not meet the above criteria of W_{NIV} and $W_{NIII} \gtrsim 2.0$ Å. In all, our search revealed 20 nitrogen-rich candidates and 31 nitrogen-salient quasars in the SDSS DR1 database.

¹The cross-correlation routine was also used in a 30 Å window centered on $\lambda 1486$ to search for emission from N IV]. However, intrinsic absorption was a large cause of noise in the results of the cross-correlation on this area of the spectra, and the results from the N III] window were deemed more robust.

2.1. Description of Candidates

The sample of candidate nitrogen-rich quasars presented here contains 20 objects that have similar features. Ten of the candidates have relatively flat F_{λ} continua, while the other 10 have slight blueward slopes. Most of the candidates are narrow-lined objects, although the FWHM of the C IV emission line ranges from $\sim 950-4300~{\rm km~s^{-1}}$, with a median FWHM of $\sim 2100~{\rm km~s^{-1}}$. All of the spectra show evidence for He II $\lambda 1640~{\rm and~O~III}$ $\lambda 1663~{\rm emission}$, which will be important diagnostics for metallicity estimates, but in most of the candidates they are too blended for preliminary measurements at the S/N afforded by the SDSS spectra.

The profiles of the Ly α emission lines (for those candidates with z > 2.3 where Ly α has redshifted into the spectrograph range) are very narrow and sharp. All of these quasars have visibly separated N V emission, and three of the seven (SDSS J0242-0038, SDSS 1059+6638, and SDSS J1550+0236) have N V emission that is relatively unblended with the Ly α emission. The FWHM of the Ly α line ranges from $\sim 1300 - 3000 \text{ km s}^{-1}$ with a median value of 1700 km s⁻¹, compared to $\sim 6100 \text{ km s}^{-1}$ for the SDSS quasar composite of Vanden Berk et al. (2001). Osmer (1980) noticed that the value of the flux ratio C IV/(Ly α + N V) was very low for Q0353-383, only 0.07 compared to average values of \sim 0.30, indicating a low carbon abundance. For the seven objects in this work with z > 2.3, the ratio of C IV/(Ly $\alpha + N$ V) ranges from 0.09 to 0.20, with a median value of 0.17. The typical error on the measurement of this ratio for each object is only ~ 0.02 , so it seems that the nitrogen-rich candidates presented here have slightly larger relative carbon abundances than Q0353-383, while still being slightly depressed relative to the rest of the quasar population, as demonstrated by the somewhat higher value of 0.31 measured for the SDSS quasar composite. It is interesting to note that the object with the lowest value of this ratio (0.09) is SDSS J1550+0236, which appears to have much stronger N IV and N III lines than the other six objects for which this ratio was calculated (see Table 2).

A composite spectrum was generated using all twenty of the candidate nitrogen-rich quasars. Each spectrum was divided by a fit to the continuum, scaling them all to a common continuum level of one. The scaled spectra were then averaged together, weighted by the S/N in the original spectra. Because of the various redshifts of the quasars, the region of overlap for all of the spectra is from $\sim 1450-2250$ Å. Figure 3 displays the resulting composite overlaid by the SDSS composite from the EDR generated by Vanden Berk et al. (2001), which has also been scaled by dividing out the continuum. This particular method is useful for comparing emission lines individually, but obviously erases any information about the differences in the shapes of the continua of the two composites. The nitrogen-rich quasars are much stronger in the N IV] $\lambda 1486$ and N III] $\lambda 1750$ emission lines, as well as Ly α . C IV and C III] seem to be slightly stronger in the nitrogen-rich quasars as well, although the FWHM of the C IV line is much smaller in the nitrogen-rich composite than in the SDSS composite, with values of ~ 2560 km s⁻¹ and ~ 4850 km s⁻¹, respectively.

Based on the equivalent widths of their N IV] $\lambda 1486$ and N III] $\lambda 1750$ emission lines, four of the 20 candidate nitrogen-rich quasars may be viewed as being similar to Q0353-383: SDSS

J0909+5803, SDSS J1254+0241, SDSS J1546+5253, and SDSS J1550+0236. Figure 4 compares these four quasars, which all have $W_{NIII} \gtrsim 7.0 \text{Å}$ and $W_{NIV} \gtrsim 4.0 \text{Å}$, compared to $W_{NIII} = 9.0 \text{Å}$ and $W_{NIV} = 5.0 \text{Å}$ for Q0353-383.

As indicated in Table 1, several of the nitrogen-rich candidates discussed in this paper are also included in the SDSS EDR Quasar Catalog (Schneider et al. 2002), although the four candidates mentioned above with the strongest emission were discovered in the area of the DR1 not coincident with the EDR. For most of the objects that were not detected by Bentz & Osmer (2004) in their study of quasars in the EDR, the EDR spectra show obvious emission from N III] $\lambda 1750$. However, there is only weak evidence for emission from N IV $\lambda 1486$, and this is easily accounted for by the noise in the spectra. Fortunately, the SDSS spectroscopic pipeline has gone through several changes resulting in much cleaner spectra in the DR1 database, as shown by the comparison of the final EDR and DR1 spectra for SDSS J1136+0110 in Figure 5. What originally appeared to be noise in the EDR spectra of these objects is now more definitely shown to be weak emission. Additionally, SDSS J1130-0045 was not detected by Bentz & Osmer (2004) because of the slight difference in the redshift cuts between the two searches. In this work, we have examined quasars with 1.6 < z < 4.1, while Bentz & Osmer (2004) only examined quasars with 1.8 < z < 4.1. At a redshift of 1.66, SDSS J1130-0045 would not have been included in the EDR study.

3. Conclusions

We have searched 6650 quasars in the SDSS DR1 database for nitrogen-rich objects similar to Q0353-383. Four candidates have nitrogen emission as strong or stronger than that seen in Q0353-383, and an additional 16 exhibit slightly weaker nitrogen emission. We have also identified 33 objects that may have visible N IV] and N III] emission, although it is less clear from the quality of their spectra.

With the data available, we may set a lower limit of 0.06% (about 1 in 1700) on the number of nitrogen-rich objects that are truly similar to Q0353-383. If we view Q0353-383 and its companion SDSS quasars as being the most extreme objects in a continuous phase of nitrogen enrichment, then it also appears that a lower limit of 0.2% - 0.7% of quasars (up to 1 in 130) are approaching the nitrogen enrichment levels of their more extreme counterparts.

If nitrogen-strong quasars are quasars viewed at the peak of metal enrichment, then the length of that phase is approximately 1/1700th of the typical quasar lifetime. For example, for a quasar lifetime of 10^7 years, these objects would be viewed only in the last 6,000 years of their existence as quasars. Alternatively, it may be that only 1 in 1700 quasars reaches the extremely high metallicities needed to generate strong nitrogen emission.

Further data and modeling outside the scope of this paper are needed to place these quasars in their correct context to the overall quasar population. For example, if these quasars are near the end of their accretion phases, or are the most metal-rich because they are in the most massive bulges, their black holes should be biased towards higher masses than randomly selected quasars. However, there is no evidence of such a bias in the widths of the emission lines, which range from narrow to average.

Additional observations should be undertaken in order to obtain higher S/N spectra for more accurate measurements of the emission lines, and also to push the observed wavelengths further into the blue in order to gain the Ly α and N V emission lines for those objects with $z\approx 2$. With such additional data, metallicity estimates may be made using line ratios such as N III]/O III], N III]/C III], and N V/He II. These estimates would allow us to test the hypothesis that nitrogen-rich quasars are exhausting their fuel supplies and approaching the metallicities predicted by numerical simulations for black holes as they end their quasar activity.

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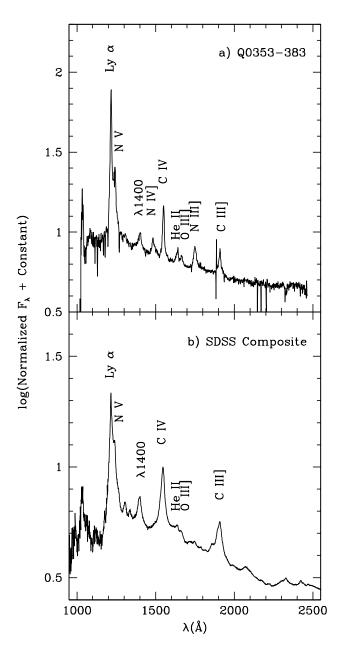


Fig. 1.— Rest frame spectra of a.) Q0353-383 (Baldwin, private communication), and b.) the SDSS composite (Vanden Berk et al. 2001), composed of 2204 quasar spectra. Both spectra are plotted in semi-log format to enhance fine details.

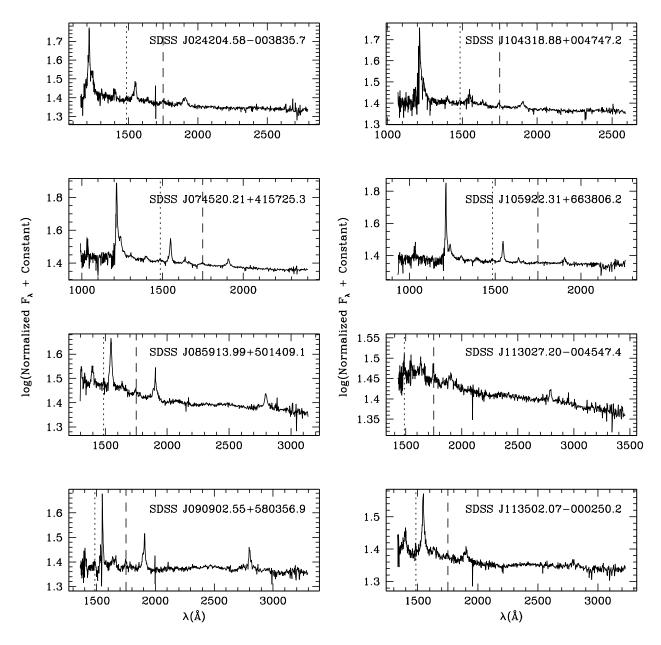


Fig. 2.— Rest frame spectra of the 20 candidate nitrogen-rich quasars from the SDSS DR1 database. The spectra are smoothed with a bin of five pixels and plotted in semi-log format to enhance fine details. The dotted line is at N IV] $\lambda 1486$ and the dashed line is at N III] $\lambda 1750$. Several of the spectra retain the signatures of night sky lines, but a handful of them also seem to have narrow absorption profiles. SDSS J0909+5803 and SDSS J1254+0241 have blueshifted absorption in Si IV, C IV, and Mg II. SDSS J2040-0545 has blueshifted absorption in Si IV, C IV, and Al III, and SDSS J1327+0035 has two blueshifted C IV absorption systems. SDSS J1043+0047 has an associated absorption system in Ly α , N V, Si IV, and C IV, as well as two other associated C IV absorbers. And SDSS J1546+5253 has an intervening Mg II and Fe II system at z=0.792, producing absorption in the Si IV and C IV emission lines.

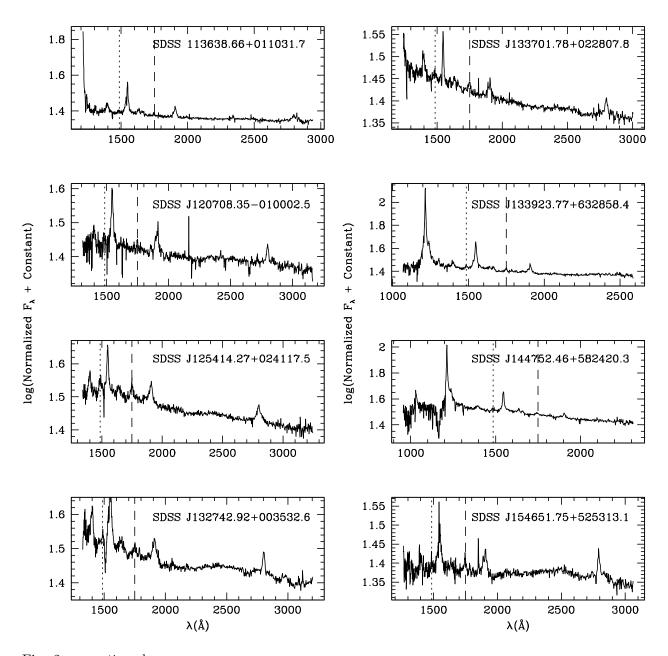


Fig. 2.— continued

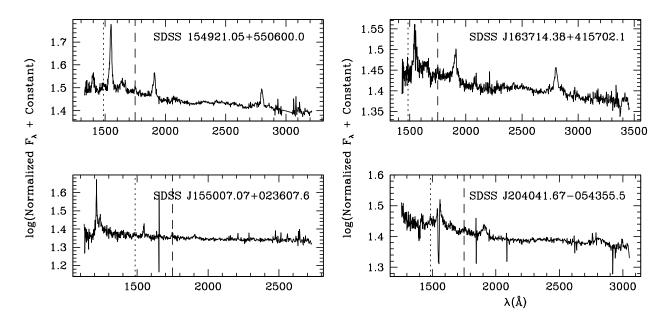


Fig. 2.— continued

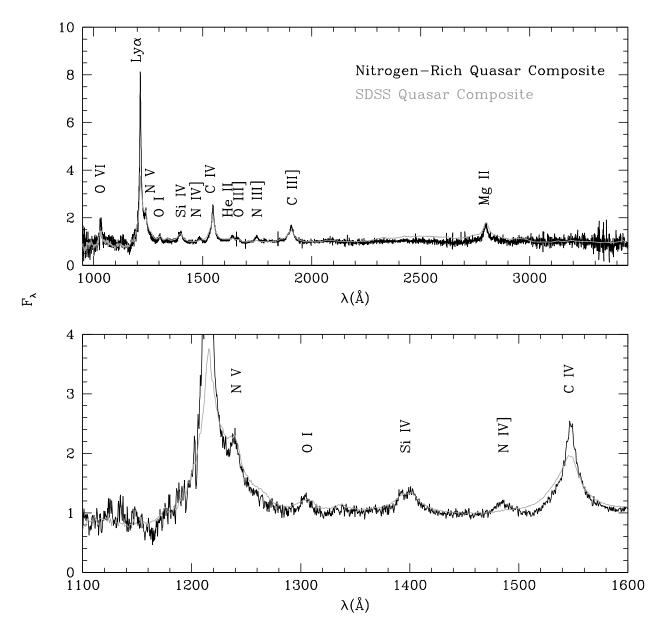


Fig. 3.— Comparison of the candidate nitrogen-rich quasar composite (black) and the SDSS quasar composite (gray). Both spectra are scaled to a continuum level of 1. The bottom window is simply a rescaled view of the region between 1100Å and 1600Å.

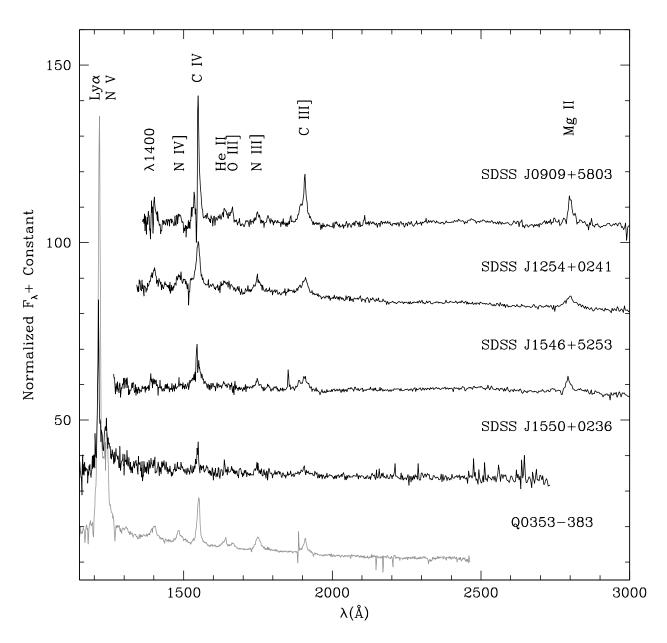


Fig. 4.— Comparison of Q0353-383 (plotted in gray) with the four strongest candidate nitrogenrich quasars discovered in the DR1. The SDSS spectra have been smoothed with a bin of five pixels, and egregious night sky lines have been removed.

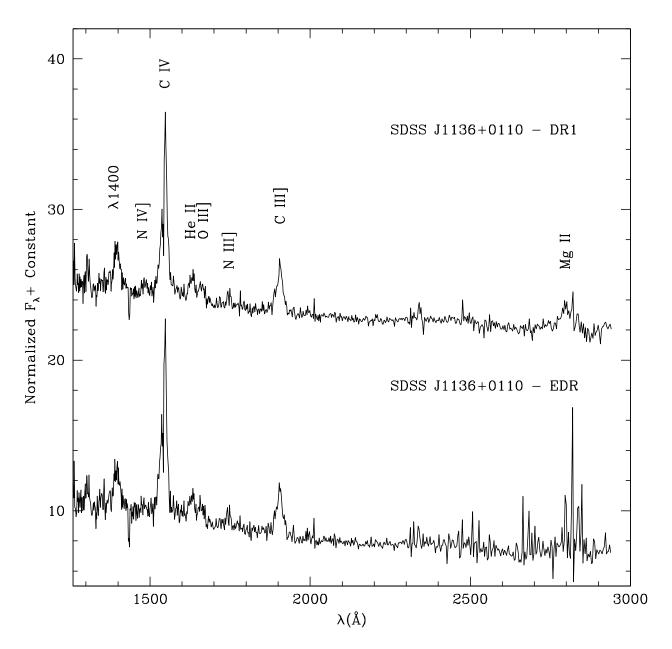


Fig. 5.— Comparison of the EDR (bottom) and DR1 (top) spectra of the candidate nitrogen-rich quasar SDSS J1136+0110. Each spectrum has been smoothed with a bin of five pixels.

Table 1. Properties of Candidate Nitrogen-Rich Quasars

Quasar (SDSS J)	z^a	i ^a	${ m M}_i{}^{ m b}$	Additional Identifier	Notes ^c	References ^d
024204.58-003835.7	2.288	19.855	-25.88	SDSS J024204.59-003835.7	EDR	1
074520.21 + 415725.3	2.843	19.116	-27.14		FIRST	2
085913.99 + 501409.1	1.930	18.932	-26.40			
090902.55 + 580356.9	1.793	18.986	-26.21			
104318.88 + 004747.2	2.558	19.277	-26.74		EDR	1
$105922.31\!+\!663806.2$	3.075	19.874	-26.49			
$113027.20 \!-\! 004547.4$	1.662	18.752	-26.24	$2QZ\ 113027.2-004548$	EDR, NRD	1, 3, 4
$113502.07\!-\!000250.2$	1.851	19.599	-25.63	SDSS J113502.08 -000250.1	EDR	1
113638.66 + 011031.7	2.131	19.449	-26.10		EDR	1
$120708.35\!-\!010002.5$	1.912	18.627	-26.68		EDR	1
125414.27 + 024117.5	1.839	18.319	-26.92		FIRST	2
$132742.92 {+} 003532.6$	1.873	18.333	-26.93		EDR	1, 5
$133701.78 {+} 022807.8$	2.068	19.167	-26.32		FIRST	2
133923.77 + 632858.4	2.559	19.270	-26.69	87GB 133745.0+634401	FIRST, FSRQ, SLC	2, 4, 6, 7
144752.46 + 582420.3	2.982	18.214	-28.07		FIRST, 2MASS	2, 8
154651.75 + 525313.1	2.011	19.057	-26.35			
154921.05 + 550600.0	1.865	18.422	-26.81		FIRST	2
$155007.07{+}023607.6$	2.371	20.064	-25.94		FIRST	2
163714.38 + 415702.1	1.665	18.784	-26.17			
204041.67-054355.5	2.023	18.901	-26.61			

^aValues taken from Schneider et al. (2003)

References. — 1. Schneider et al. (2003), 2. Becker et al. (2003), 3. Croom et al. (2001), 4. Véron-Cetty & Véron (2001), 5. Bentz & Osmer (2004), 6. Vermeulen & Taylor (1995), 7. Becker et al. (1991), 8. Cutri et al. (2003)

^bAs determined by Schneider et al. (2003), with $H_0=70,\,\Omega_M=0.3,\,\Omega_\Lambda=0.7,$ and $\alpha_Q=-0.5$

 $^{^{}c}$ Abbreviations: EDR = SDSS Early Data Release source; FIRST = Faint Images of the Radio Sky at Twenty-Centimeters source; NRD = not detected in radio; FSRQ = flat spectrum radio quasar; SLC = superluminal candidate; 2MASS = Two Micron All Sky Survey source

^dThis research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Table 2. Measured Equivalent Widths N IV] $\lambda 1486$ and N III] $\lambda 1750$

	-	N IV]			N III]		
Quasar	$\mathrm{S/N^a}$	$W(\mathring{\mathbf{A}})^{\mathrm{b}}$	$\sigma^{ m c}$	$\mathrm{CCC^d}$	$W(\mathring{\mathbf{A}})^{\mathrm{b}}$	$\sigma^{ m c}$	$\mathrm{CCC^d}$
$Q0353 - 383^{e}$		5.0		0.98	9.0		0.99
SDSS J0242 -0038	5.0	2.0	1.8	0.22	8.0	7.3	0.68
SDSS J0745 $+4157$	8.1	3.0	4.4	0.39	4.0	5.9	0.86
SDSS J0859 $+5014$	9.4	2.0	3.4	0.35	3.0	5.1	0.76
SDSS J0909+5803	4.1	4.0	3.0	0.31	8.0	6.0	0.85
SDSS J $1043+0047$	8.4	3.0	4.6	0.41	5.0	7.7	0.71
SDSS J1059+6638	5.6	4.0	4.1	0.47	4.0	4.1	0.59
SDSS J1130 -0045	8.5	3.0	4.7	0.00	4.0	6.2	0.75
SDSS J1135 -0002	5.0	4.0	3.7	0.06	6.0	5.5	0.80
SDSS J1136 $+0110$	6.8	3.0	3.7	0.22	3.0	3.7	0.53
SDSS J1207 -0100	5.7	5.0	5.2	0.31	3.0	3.1	0.66
SDSS J1254 $+0241$	11.3	7.0	14.4	0.68	8.0	16.5	0.93
SDSS J1327 $+0035$	9.6	3.0	5.3	0.46	5.0	8.8	0.94
SDSS J1337 $+0228$	11.8	3.0	6.5	0.52	4.0	8.6	0.83
SDSS J1339+6328	8.6	4.0	6.3	0.63	4.0	6.3	0.70
SDSS J $1447+5824$	16.1	2.0	5.9	0.12	3.0	8.8	0.78
SDSS J1546 $+5253$	4.6	4.0	3.4	0.43	11.0	9.2	0.91
SDSS J1549 $+5506$	10.5	5.0	9.6	0.35	2.0	3.8	0.84
SDSS J1550 $+0236$	3.5	7.0	4.5	0.36	7.0	4.5	0.41
SDSS J $1637+4157$	5.6	2.0	2.0	0.00	3.0	3.1	0.63
SDSS J2040 -0545	7.7	3.0	4.2	0.71	6.0	8.4	0.65

 $^{^{\}rm a} Signal$ -to-noise ratio of the SDSS spectrum, measured between $\lambda 1675$ and $\lambda 1725 {\rm Å}$ before smoothing.

 $^{^{\}rm b} \rm Guideline$ measurements in the quasar rest frame. Errors are estimated to be 0.5-1.0 Å.

 $^{^{\}mathrm{c}}$ Significance of detection, assuming a 30Å window in the quasar rest frame

 $^{^{\}rm d} \rm Cross\text{-}correlation$ coefficients for the 30 Å windows as described in the text; auto-correlation coefficients for Q0353-383

^eValues taken from Baldwin et al. (2003)

Table 3. Properties of Nitrogen-Salient Candidate Quasars

Quasar (SDSS J)	z^a	i ^a	${ m M}_i{}^{ m b}$	Additional Identifier	Notes ^c	References ^d
003815.93+140304.6	2.718	19.794	-26.39			
004833.56 + 142056.8	1.816	18.608	-26.67			
010527.72 + 143701.3	1.939	19.171	-26.22			
012310.96 - 084053.7	1.634	19.271	-25.71			
014517.79 + 135602.2	1.949	18.866	-26.55			
$022129.05\!-\!083351.0$	1.876	20.170	-25.10			
022203.24 - 091531.4	1.742	18.948	-26.14			
$025713.07\!-\!010157.8$	1.869	19.190	-26.15	[CLB91] 025440.2-011	EDR, pROSAT	1, 2, 3, 4
$025939.26\!-\!063158.4$	2.012	19.471	-26.04			
033832.65 + 004518.5	1.839	19.240	-26.10	SDSS J033832.65+004518.4	EDR	1
040913.78 + 060839.0	2.685	19.210	-26.98			
073048.37 + 371616.3	1.676	19.672	-25.39		FIRST	5
073506.59 + 374014.1	2.012	18.966	-26.52			
091031.35 + 010151.9	2.013	18.676	-26.76			
091745.24 + 555935.0	1.961	19.060	-26.31			
$092225.69\!+\!611530.6$	2.227	18.472	-27.19			
092541.46 + 004040.9	1.935	19.681	-25.67			
092754.17 + 582811.6	1.847	18.775	-26.47			
093510.60 + 593937.3	1.816	19.142	-26.04			
102949.50 + 643835.9	1.870	19.781	-25.45			
$103013.61{+}010056.4$	2.053	18.882	-26.65		EDR	1
113012.38 + 003314.7	1.932	19.492	-25.85		EDR	1
115357.27 + 002754.0	1.672	19.094	-25.90		EDR	1
$121933.26 {+} 003226.4$	2.871	19.341	-26.89	SDSS J121933.25+003226.5	EDR, FIRST	1, 5
$122348.22 {+} 010221.9$	1.942	18.616	-26.74		EDR	1
124727.25 + 033009.9	1.635	19.120	-25.82			
$125134.59\!+\!681824.2$	1.662	19.055	-25.91			
$125925.03\!+\!642139.6$	1.948	19.235	-26.10			
141857.12 + 635524.4	3.117	19.532	-26.86			
$155003.71{+}031325.0$	1.788	17.648	-27.75		${\rm FIRST,2MASS}$	5, 6
$210255.16 {+} 064112.2$	2.109	19.289	-26.38			

^aValues taken from Schneider et al. (2003)

^bAs determined by Schneider et al. (2003), with $H_0 = 70$, $\Omega_M = 0.3$, $\Omega_{\Lambda} = 0.7$, and $\alpha_Q = -0.5$

 $^{^{}c}$ **Abbreviations:** EDR = SDSS Early Data Release source; pROSAT = pointed ROentgen SATellite source; FIRST = Faint Images of the Radio Sky at Twenty-Centimeters source; 2MASS = Two Micron All Sky Survey source

^dThis research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and

 ${\bf Space}~{\bf Administration}.$

References. — 1. Schneider et al. (2003), 2. Vignali et al. (2003), 3. Véron-Cetty & Véron (2001), 4. Cristiani et al. (1989), 5. Becker et al. (2003), 6. Cutri et al. (2003)